Session: PS-TuA7 Effect of Energetic Ions on Plasma Damage of SiCOH Low-k Material **Abstract # 819**

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Abstract:

In the semiconductor industry, the number of transistors per unit area has steadily increased over the past 40 years according to Moore 's Law. As a consequence, the distance between interconnecting copper lines has reached the dimensions where capacitive coupling between the lines becomes important. To reduce capacitive coupling, low-capacitive materials, so-called low-k materials, have been investigated and integrated. A lower capacitive value can be achieved by making hydrophobic porous materials from low polarizable molecules. However, during integration these materials are exposed to etch and strip plasmas, which results in a plasma damaged material with an increased k-value. In this study we want to shed light on the mechanism of how bombarding ions and chemically active radicals damage low-k materials.

As low-k, a SiOCH- based material was deposited on 300mm Si wafers, and porogen material was removed by UV curing, resulting in a 180 nm- thick layer with a porosity of 33%. Since the focus is on revealing the mechanisms and not limiting the damage, we use a pure oxygen plasma of which the damaging capabilities are well known. A transformer coupled plasma reactor, Lam Versys (r) 2300 (r), is used for exposure. This etch chamber allows a separated control of the power from the coil (top power or ‘TP’) on the one hand, and the power fed into the plasma through the wafer (bottom power or ‘BP’). While TP results in dissociation of molecules, BP determines the bias voltage over which ions are accelerated to the wafer. Three conditions have been investigated: Bottom Power Only (BPO), Top Power Only (TPO) and Top Power and Bottom Power (T&BP), flow and pressure were kept constant. The photoresist etch rate for the different conditions was measured and the low-k wafers were exposed to the different plasma conditions using a normalized exposure time. The exposed layers were analyzed by Fourier Transformed Infrared Spectroscopy (FTIR), Water Contact Angle (WCA), Spectroscopic Ellipsometry (SE), Time Of Flight Secondary Ion Spectroscopy (TOFSIMS), Energy Filtered Transmission Electron Microscopy (EFTEM), Water and Toluene Based SE and mass measurements.

It was shown that the bombarding ions densify and seal the top layer, which makes it more difficult for the oxygen radicals to penetrate into the low-k and damage it. As a function of time, all applied conditions obey a logarithmic oxidation equation. A model that explains the equation is proposed: the oxygen radicals recombine to oxygen molecules in the damaged layer through surface reactions leading to an exponential decrease in radical concentration with depth resulting in the logarithmic time dependence.

Note: Requested an Oral Session.